Semester	**:**	**IV**		
Course No.	**:**	**REE-243**	**Credit Hrs.**	**: 3(2+1)**
Course Title	**:**	**Renewable Energy Sources**		

SYLLABUS

Objectives : (i) To make the students acquainted with the different renewable energy sources.

(ii) To enable them to analyse and select the appropriate technology to meet the energy demand in different types of agricultural operations.

THEORY

Different sources of renewable energy: Concepts and limitations of different renewable energy sources (RES) such as solar, wind, geothermal, biomass, ocean energy sources; Criteria for assessing the potential of RES; Comparison of renewable energy sources with non-renewable sources.

Solar energy: Energy available from the sun, solar radiation data, solar energy conversion into heat through flat plate and concentrating collectors, different solar thermal devices, principle of natural and forced convection solar drying system; Solar photo-voltaics: basics and applications, p-n junctions; Solar cells, PV systems, stand-alone, grid-connected solar power station; Calculation of energy through photovoltaic power generation and cost economics.

Wind energy: Energy availability, general formula, lift and drag; Basics of wind energy conversion, effect of density, frequency variances, angle of attack, wind speed, types of windmill rotors, determination of torque coefficient, induction-type generators; Working principle of wind power plant. Wind farms, aero-generators wind power generation system.

Biogas: Basic of anaerobic digestion, types and constructional details of biogas plants, biogas generation and its properties, factors affecting biogas generation and usages, design considerations, advantages and disadvantages of biogas spent slurry, Generation of power from biogas, Design and use of different commercial biogas plants.

Power generation from urban, municipal and industrial waste, Ocean thermal and electrical power generation, wave and tidal power, Power generation from biomass (Gasification and Dendro-thermal); Mini- and micro-hydel plants, Fuel cell and its associated parameters.

PRACTICAL

Study of solar thermal devices like solar cookers; Study of solar water heating system; Study of natural convection solar dryer; Study of forced convection solar dryer; Study of solar desalination unit; Study of solar greenhouse for agriculture production; Study of cost economics of solar thermal devices including solar panels; Study of solar photovoltaic system and study of characteristics of solar photovoltaic panel; Study of evaluation of solar air heater/dryer; Study of biogas plants and its components; Performance evaluation of a fixed dome type biogas plant; Performance evaluation of floating drum type biogas plant; Study of biomass gasifiers; Study of cost economics of biogas system; Visit to a windmill plant.

TEACHING SCHEDULE

THEORY [REE-243]

Lecture No.	Topic	Sub-topics/ Key Points	Weightage (%)
1 - 2	**Renewable Energy Sources**	Concepts and Limitations *viz*; solar, wind, geothermal, biomass, ocean energy sources; Criteria for assessing the potential, Classification, Comparison of with non-renewable sources	10
3 - 7	**Solar Energy**	Energy available from the sun, Solar radiation data Solar energy conversion into heat through flat plate and concentrating collectors. Principal components, working and uses of different solar thermal devices *viz*. Solar cooker, Solar water heater, Solar Distillation, Solar Dryer. Principle of natural and forced convection solar drying system.	20
8 - 12	**Solar Photovoltaics**	Basics and Applications; p-n junctions, Solar cells, PV systems; Stand-alone, grid-connected solar power station. Calculation of energy through photovoltaic power generation and cost economics.	10
13 - 18	**Wind Energy**	Energy availability, General formula, Lift and drag forces. Basics of wind energy conversion, effect of density, frequency variances, angle of attack, wind speed. Types of windmill rotors, Determination of torque coefficient, Induction-type generators, Working principle of wind power plant, Wind farms, Aero-generators wind power generation system.	20
19 - 22	**Biogas**	Basic of Anaerobic digestion, Types and constructional details of biogas plants, Biogas generation and its properties, Factors affecting biogas generation and usages, Design considerations, advantages and disadvantages of biogas spent slurry. Generation of power from biogas, Design and use of different commercial biogas plants. Power generation from urban, municipal and industrial waste.	20
23 - 26	**Gasification**	Power generation from biomass- (Gasification and Dendro-thermal),	10
27 - 32	**Other Renewable Energy Sources**	Electrical power generation from- Ocean thermal energy conversion: - Wave and tidal - Mini- and micro-hydel plants, Fuel cell and its associated parameters.	10
		Total =	**100**

TEACHING SCHEDULE

PRACTICAL [REE-243]

Exercise No.	Exercise Title
1	Study of solar cookers.
2	Study of solar water heating system.
3	Study of natural convection solar dryer.
4	Study of forced convection solar dryer.
5	Study of solar desalination unit.
6	Study of solar greenhouse for agriculture production.
7	Study of cost economics of solar thermal devices including solar panels.
8	Study of solar photovoltaic system.
9	Study of characteristics of solar photovoltaic panel.
10	Study of evaluation of solar air heater/dryer.
11	Study of biogas plants and its components.
12	Performance evaluation of a fixed dome type biogas plant.
13	Performance evaluation of floating drum type biogas plant.
14	Study of cost economics of biogas system.
15	Study of biomass gasifiers.
16	Visit to a windmill plant.

Suggested Readings [REE-243]:

1. Basu P. 2018. Biomass Gasification and Pyrolysis Practical Design and Theory. Academic Press.
2. Deublein D. and Steinhauser A. 2008. Biogas from Waste and Renewable Resources. WILEY-VCH Verlag GmbH and Co. KGaA, Weinheim.
3. Duffie J.A. and Beckman W.A. 2013. Solar Engineering of Thermal Process. John Wiley and Sons.
4. Julian Chen C. 2011. Physics of Solar Energy. John Wiley and Sons, Inc.
5. Khan B.H. 2006. Non-Conventional Energy Resources. The McGraw Hill Publishers.
6. Knothe G, Gerpen J.V. and Krahl J. (Eds.). 2010. The Biodiesel Handbook. AOCS Press.
7. Patel M.R. 2005. Wind and Solar Power Systems. CRC Press, Boca Raton.
8. Rai G.D. 2013. Non-Conventional Energy Sources. Khanna Publishers, New Delhi.
9. Rai G.D. 2020. Solar Energy Utilization. Khanna Publishers, New Delhi.
10. Reed T.B. and Das A. 1988. Handbook of Biomass Downdraft Gassifier Engine Systems. SERI, USA.
11. Ryszard Petela. 2010. Engineering Thermodynamics of Thermal Radiation for Solar Power Utilization. The McGraw-Hill Companies.
12. Stefan C.W. Krauter. 2008. Solar Electric Power Generation – Photovoltaic Energy Systems. Springer.